THE PATHOGENESIS OF INTERMITTENT EXOPHTHALMOS*

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Intermittent exophthalmos is a rare but striking and unmistakable syndrome. It is characterized by pronounced and rapid—almost instantaneous—protrusion of one eye when venous stasis is induced by bending the head forward, by lowering the head, by turning the head forcibly, by hyperextension of the neck, by coughing, by forced expiration with or without compression of the nostrils, and by pressure upon the jugular veins. The ocular protrusion disappears immediately when the head is erect and when artificially induced venous congestion is relieved.

Usually, but not invariably, there is enophthalmos when venous congestion does not obtain. There may or apparently (from cases reported in the literature) may not be pulsation of the eyeball. The vision may or may not be affected. The condition is progressive and may be productive of unbearable pain and troublesome diplopia. The appearance is unsightly but life is not at stake.

The case here reported—the only one we have seen—is presented because the pathologic findings were disclosed at operation. Most of the cases hitherto reported are mainly clinical presentations and are not followed by detection of the underlying lesion. Orbital operations have been performed in

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a few cases and venous beds have been described in the orbit. These may or may not represent the whole pathologic picture. No postmortem examinations have been made.

CASE REPORT

The patient, a white girl, aged 18 years, was referred by Dr. Milton Little of Hartford, Conn.

Complaint.—Bulging of the left eye induced by posture and associated with pain in the head.

Family and past histories were negative.

Present Illness.—From the age of 10 she had known that her left eye was sometimes more prominent and at other times less prominent than her right eye. When she sat erect or stood the left eye became sunken. When she lay down it bulged. When she became excited it protruded. For 6 months, every morning on awakening, there had been a throbbing pain in the eye which disappeared soon after getting up. The pain disappeared after rest in bed for a week but upon resumption of her usual activities soon returned. For a week there had been severe pain in the left eye and left temple. Throbs were noted to occur at the same rate as the heart beat. From the age of 10 there had been occasional periods when diplopia was present but strabismus or ptosis had not been observed.

Examination.—When the patient stood there was striking enophthalmos. Immediately after lying down the eye commenced to protrude and a pronounced exophthalmos persisted throughout the recumbent period. Moreover, the eyeball pulsated; this was visible and palpable. When she leaned forward (head down) the exophthalmos became extreme. This was also true when the jugular veins were compressed or when she blew her nose. The exophthalmos was also increased when the common carotid was compressed (because the internal jugular vein was then also compressed) but the pulsation ceased. There was no audible bruit.

There was weakness of the left external and inferior rectus muscles and absence of ptosis when the patient was sitting erect. When the eye was protruded as a result of change of position of the head, ptosis appeared. Measurements were made with the Hertel exophthalmometer. There was enophthalmos of 3 mm. (Fig. 1A) when the head was erect (sitting or standing); R. E. 15, L. E. 12 mm.). There was exophthalmos of the left eye: 6 mm. when lying recumbent (Fig. 1B), 11 mm. when the head was tilted forward or the jugular vein compressed (Fig. 1C), 18 mm. when expiration

was forced and nostrils were compressed (standing) (Fig. 1D), 5 mm. when the head was turned forcibly to the left, 3 mm. when it was turned to the right. The visual acuity was: R. E. V. = 20/15; L. E. V. = 20/30 (sitting upright). The left pupil dilated slightly when the eyeball protruded. The eyegrounds were normal excepting for slight overfilling of the retinal veins of the left eye when that eye was maximally protruded.

X-rays showed thickening of the superior margin of the left orbit, which was increased in density, as was the left wing of the sphenoid. The sphenoidal fissure was widened (Fig. 2). A small diffuse area of calcification was visible in the outer orbit.

Diagnosis.—1. The quick protrusion and sinking of the eyeball with the postural changes, and the rapid protrusion induced by coughing, sneezing, and jugular compression could only mean filling of a large venous bed.

2. The pulsation of the eyeball indicated an arterial component. The lesion therefore had to be an arteriovenous aneurysm.

3. The absence of a murmur indicated that the communication between arteries and veins was through vascular "coils" and not through a fistula.

4. The enophthalmos (sitting or standing) was thought to be due to atrophy of the orbital fat from long-continued pressure.

5. The most puzzling point was the absence of exophthalmos when the patient was erect. Coiled vessels would be expected to produce a space-occupying mass in the orbit. The explanation of this was found at operation. The coils making a space-occupying mass were in the cranial chamber and not in the orbit.

Operation (July 24, 1943—W.E.D.).—A frontotemporal approach to the cranial chamber was made—a typical hypophyseal approach. When the dura was turned back, a fingerlike projection of vascular coils was found extending from the region of the pterion backward and mesially and finally paralleling the sylvian vein. A few minor vascular attachments to the brain were thrombosed with the electrocautery, after which the brain was free of attachment to the dura. The cerebral vessels were unaffected and of normal size. In the region of the sphenoidal fissure and the anterior part of the middle fossa was a mass of coiled vessels (Fig. 3); this overflowed the sphenoidal wing and extended a short distance over the orbital plate (about 1 cm.) as a thin pink film (arterial blood) that blanched with slight pressure. The mass was intimately grown into and inseparable from the dura and was made up of intertwining coils of vessels easily compressible like a sponge and immedi-

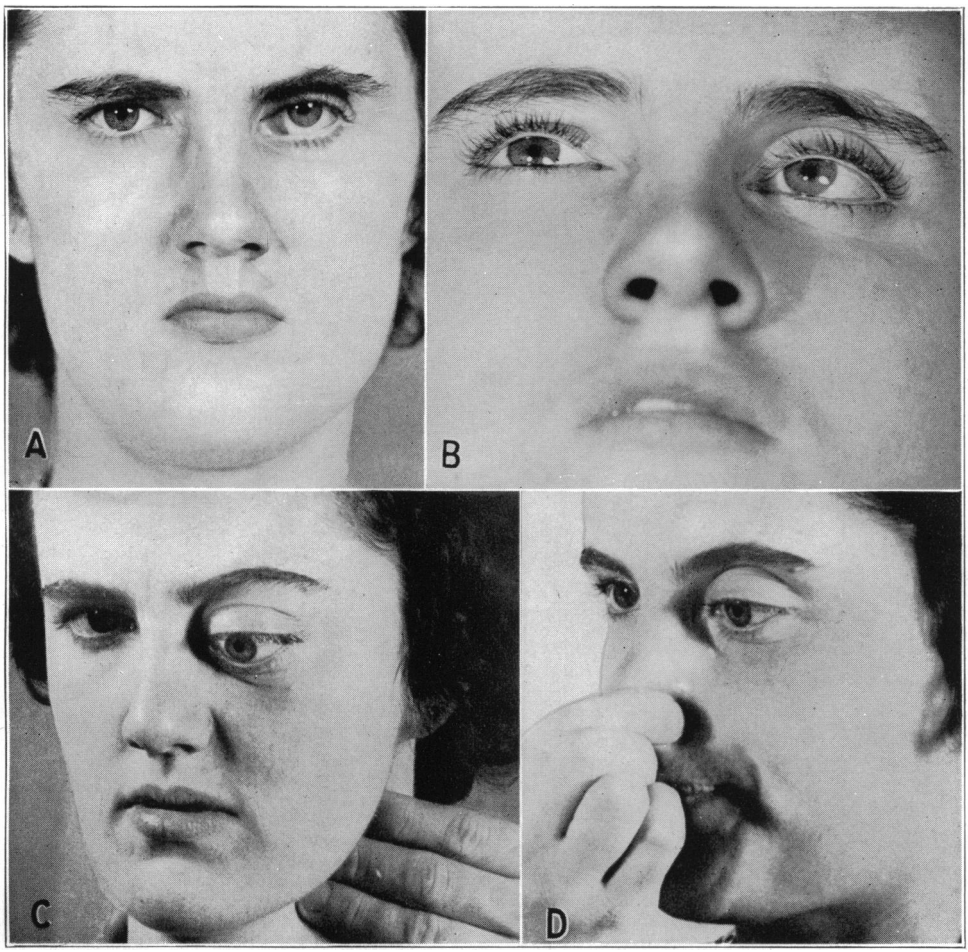

Fig. 1A.—Patient in erect position showing difference in the palpebral fissures. There is pronounced enophthalmos on the left.

B.—Degree of exophthalmos when patient is recumbent.

C.—Exophthalmos and downward protrusion of the eyeball from pressure on the juglar vein.

D.—Exophthalmos induced by forced expiration when the nose is closed.

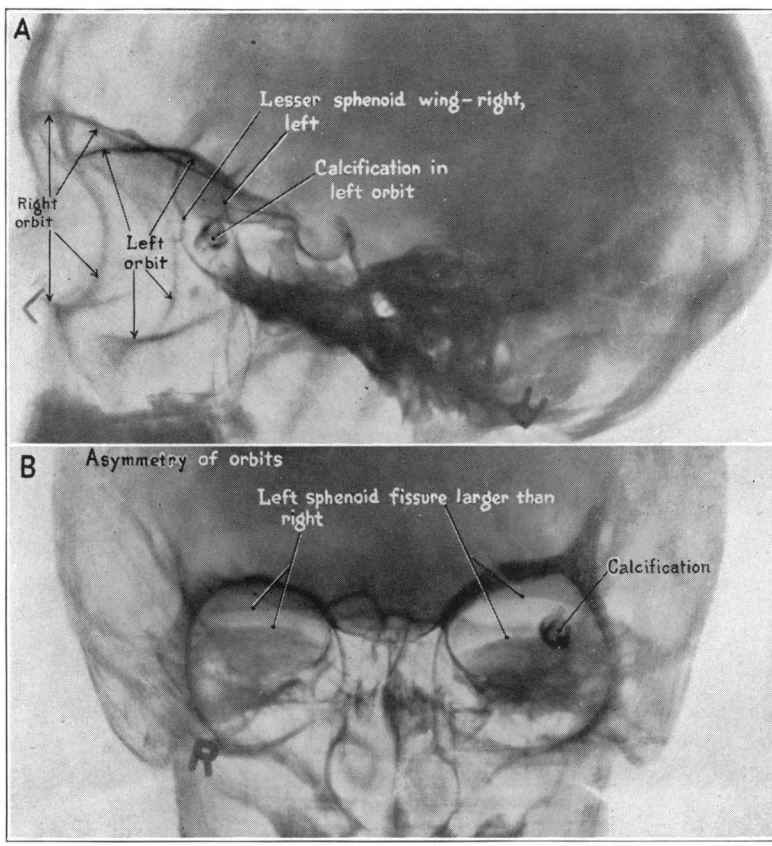

Fig. 2.—Retouched x-rays of the orbit showing area of calcification and a widening of the left sphenoidal fissure.

ately returning to the original size when pressure was released. The vascular mass was repeatedly attacked by the electrocautery and the volume gradually shrank until the scar was flush with the sphenoidal fissure.

From time to time the cautery cut through the vessels and brisk arterial bleeding ensued. The bleeding areas were covered with pieces of muscle and the coagulation carried through them. The sphenoidal fissure was markedly widened and filled with the vascular coils but no attempt was made to carry the cauterization forward into the orbit, there being no reason to believe that a mass was located therein. Because of diffuse dural bleeding the middle meningeal artery was isolated and coagulated at the foramen spinosum. It was our impression that the arterial component of the arteriovenous aneurysm arose from this vessel because of its intimate relationship to the coiled mass and because no other large artery was nearby. The intracranial division of the internal carotid artery was distant and was entirely normal. The optic nerve was in full view, not implicated, and was not injured at any time. The aneurysmal mass completely covered the dura over the gasserian ganglion and cavernous sinus. It could not be determined whether or not there were communications with the latter. That there were no communications with the internal carotid artery in the cavernous sinus cannot be stated dogmatically but this could be possible only through an anomalous branch. It was realized throughout the operation that the nerves to the extra-ocular muscles lying in the cavernous sinus and the sphenoidal fissure were passing through the vascular mass that was being coagulated, and that their injury or even destruction was a distinct possibility. However, the cure of the aneurysm was thought to be advisable in view of the progressively increasing pain.

Postoperative Course.—Immediately after operation the eyeball was free of all the intermittent changes that previously obtained with posture, blowing the nose, jugular pressure, etc. However, the vision was entirely lost in the left eye and all the extra-ocular muscles were paralyzed. The pupil did not respond to direct or consensual light stimulation. Three months later the intermittent exophthalmos remained cured but the extra-ocular paralyses remained in part. The pupil exhibited a consensular reaction. There was enophthalmos of 3 mm. The upper lid could be elevated incompletely, and internal and downward rotation of the eyeball had improved to about half-normal. The price of a cure was, therefore, high, but the patient is happy over the end-result. We have

wondered whether it would have been practical and preferable to have attempted ligation of the orbital veins in the orbit (through the same transcranial approach) and to have left the aneurysm untouched. The practicability of this procedure is uncertain but even if successful the pulsation of the eyeball would have persisted.

Note: The patient was seen again ten months after discharge from the hospital. There had been no discomfort except on one occasion, three weeks before re-examination, when she had a severe pain in the head. She stated that at this time there was some protrusion of the left eye.

Examination revealed incomplete ptosis and inward deviation of the eye of about 30 degrees. She was unable to elevate the left eye but could lower it 20 or 30 degrees. The eye was blind and the nerve atrophic. There was enophthalmos of the left eye, which was not influenced by such factors as position and pressure on the jugular vein.

SYMPTOMATOLOGY AND BRIEF REVIEW OF THE LITERATURE

Intermittent exophthalmos has been recognized as a clinical entity since 1805, when it was first described in an infant. In a classic paper, Birch-Hirschfeld reviewed the literature up to 1906 and presented observations of prime importance, not only concerning the intermittent exophthalmos but also the anteroposterior position of the normal eye in relation to various positions of the head. He described the syndrome in a physician, Dr. Minor, who also wrote regarding it. Wissmann and Schulz (1922) added a single case and collected the cases appearing between 1906 and 1922, a total of 74. Kraupa and Mendl (1936) described a case and brought the cases in the literature to 96. They rejected 2 cases included by Wissmann and Schulz.

The following reported cases of intermittent exophthalmos have been found since Kraupa and Mendl's publication and also include 2 not mentioned by them: Bartók (1931), Chapman (1931), De Petri (1935), Marchesini (1935), Hippert (1936), Muirhead (1936), Lipowitsch (1936), Petrov (1939), Spektor (1939), Giqueaux (1942), Poole (1942), Dunphy (1942), and Rones (1942). The 2 last-named cases

were mentioned in the discussion of Poole's paper. Rychener (1942) and Ellett (1942) made subsequent reports on Chapman's case. These plus our case bring the total to 111.

From the clinical viewpoint but little has been added since Birch-Hirschfeld's comprehensive publication.

Occurrence.—As the above figures indicate, true intermittent exophthalmos is rare. Birch-Hirschfeld saw a single case among 150,000 ophthalmologic patients, De Schweinitz, 1 case among 100,000, and the case described here is the only example of the condition recorded in the Johns Hopkins Hospital. Krauss, Hippert, and Weissner each encountered 2 cases. In the United States and Canada the condition has been described by Sattler, De Schweinitz, Byers, Chapman, Ellett, Poole, Dunphy, Rychener, and Rones.

Sex.—Possibly more men than women are victims of this condition. Birch-Hirschfeld's series contained 35 men and 15 women. In Kraupa and Mendl's collection there were 10 males and 8 females.

Trauma.—This has been suggested as a factor in the development of intermittent exophthalmos but it is difficult to believe it could play more than a precipating role. The patient described by Rumjanzewa was first observed to exhibit the syndrome during childbirth.

Age of Onset.—Since individuals with intermittent exophthalmos may be wholly unaware of its existence until it has been pointed out to them, it is impossible to obtain accurate information regarding the age of onset. It has been observed in infants and it has been observed for the first time during the sixth decade of life (Birch-Hirschfeld). Sattler thought it occurred in young persons almost or quite exclusively, but there is ample evidence that this concept is erroneous. Birch-Hirschfeld found records of 6 cases occurring during the first decade, 7 during the second, 8 in the third, 1 in the fourth, 2 in the fifth, and 1 in the sixth decade. In cases reported since 1935 there have been 3 during the second decade, 4 in the third, 5 in the fourth, and 2 in the fifth.

Unilaterality.—All reported cases have been unilateral. Poole remarked that the left eye is involved 10 times to one of the right. This large ratio is not upheld by Birch-Hirschfeld's compilations, although he considered that the left eye was affected more often than the right. Kraupa and Mendl found the right eye affected in 10 and the left in 8 cases. In the 13 cases described since 1935, the left eye was affected in all. Excellent accounts regarding intermittent exophthalmos of the right eye have been written by Byers and Rumjanzewa.

It is natural that attempts have been made to explain the predominance of left-sided involvement. Reese suggested that the jugular foramen on the left is frequently smaller than on the right, but this is remote from the lesion producing the venous changes and can have no bearing in its causation. There is no apparent reason why a congenital lesion such as that causing this condition should favor one side.

The Exophthalmos: Its Direction and Degree.—The complete syndrome of alternating exophthalmos and enophthalmos usually develops gradually and progressively. Radswitzki described exophthalmos which at first occurred only as a result of severe coughing or vomiting up to the age of 14 years, but thereafter changed position of the head, holding the breath, etc., was sufficient to induce the changes which rapidly disappeared when the head resumed the erect position. Mulder described the case of an individual who until the age of 12 years exhibited intermittent exophthalmos only when he wore a tight collar, but later developed the complete syndrome. Mention has already been made regarding Rumjanzewa's case in which the anomaly was developed during the strain of childbirth.

The eye may be protruded either directly forward or down and outward. In a majority of reported cases mention is made only of direct protrusion. According to Birch-Hirschfeld the superior ophthalmic vein is usually larger than the inferior ophthalmic and consequently the eye is usually pushed downward and outward as well as forward. The position of

the eyeball is doubtless dependent upon the symmetry or asymmetry of the venous bed in the orbit.

Narrowing of the palpebral fissure during the episodes of exophthalmos was observed in Poole's, Rumjanzewa's, and our patient. During the stage of enophthalmos the palpebral fissures of both sides were quite or almost equal in width. Probably Dunphy's suggestion that during exophthalmos there may be some voluntary or reflex closure of the lids as a protective measure, is correct.

The amount of proptosis has been noted to vary within wide limits in different cases. Sattler and De Vincentiis observed 25 and 29 mm., respectively, in their patients when the head was bent forward. In our case, 18 mm. of relative exophthalmos was observed when the patient exhaled forcibly with the nostrils compressed, but this did not represent what could have been obtained since it was thought unwise to attain the maximum. It may be remarked that measurements of exophthalmos as usually made are only approximate; special photographic apparatus such as that described by Birch-Herschfeld is necessary for accuracy.

The time required for proptosis to begin is not available in most reported cases. Birch-Hirschfeld observed a latent period of 5 seconds which was followed by protrusion of the eye reaching almost its maximum in 30 seconds and its maximum in a further 15 seconds. His patients had the head bent forward. He remarked upon the latent period having been stated as being from 1 to 5 minutes but it must rarely, if ever, be so long.

Factors Influencing Exophthalmos.—Often, as in our patient, the condition has first been observed by a friend. Birch-Hirschfeld observed protrusion of the normal eye when the head was bent forward. This is, of course, due to gravity and is intensified when an abnormal venous bed exists.

Proptosis can be produced in most instances by pressure over the jugular vein on the side of the intermittent exophthalmos. In our patient this produced about as much prop-

tosis as did bending the head forward. Occasionally, as in Lindenmeyer's case, pressure over the contralateral vein produced proptosis when similar pressure over the homolateral jugular vein failed to do so. In such instances either there is great congenital narrowing or absence of the homolateral jugular vein, or it has become thrombosed.

The position of the head in lateral rotation has been found to influence the position of the eye owing to a degree of jugular constriction. Mann observed that rotation of the head to the right produced maximal venous drainage through the left jugular vein, and conversely, rotation of the head to the left produced maximal venous drainage through the right jugular vein. In our case forcible turning of the head produced exophthalmos of the affected eye which was more pronounced when the head was turned to the left. In Poole's photographs the effect is most striking.

Birch-Hirschfeld surmised that any obstruction to the anterior venous pathways outside of the orbit resulted in additional pressure in the ophthalmic veins, and to prove it, he devised an ingenious experiment by which the extra-orbital veins were compressed. This, however, could have no bearing upon the intermittency of the exophthalmos. Krauss assumed that large congenital orbital varicosities might cause intermittent exophthalmos. He also assumed that an obstruction to the drainage of orbital blood, either anteriorly as suggested by Birch-Hirschfeld, or posteriorly could produce intermittent exophthalmos. Both of these observers remarked upon the narrowness of the ophthalmic vein just before it enters the cavernous sinus, and Krauss remarked upon there being a pronounced constriction of the superior ophthalmic vein where it lies close to the tendon of the superior oblique muscle. However, an obstruction to the veins is the one thing that cannot explain this condition; the prompt appearance of proptosis with jugular compression means that there is no obstruction in the venous channels. All textbooks are in agreement that there are no valves along the ophthalmic

vein. There could not, of course, be any effective valves in the intermittent exophthalmos because pressure on the jugular immediately produces the ocular protrusion.

Enophthalmos.—Enophthalmos is not essential to the diagnosis but it is usually present. It can be due only to absorption of orbital fat from pressure of the vascular bed (probably venous) in the orbit. Enophthalmos, when present, is apparent only when the head is in the erect position.

Lids, Temporal Region, and Face.—It might well be expected that there would be some engorgement or at least prominence of the veins of the eyelids, temple, and face on the side of the anomaly since they are in communication with the orbital veins. However, this is only occasionally observed and was not present in our case. Some swelling of the lids may be observed when the eye is proptosed. The temporal region was engorged during proptosis in Marchesini's case, and the homolateral side of the face was swollen in Petrov's case. In Rumjanzewa's patient there was flushing of the side of the face when the eye was protruded.

In no instance, so far as we are aware, have there been great dilated veins over the face and lids or over the scalp, as are so commonly observed in cases of carotid-cavernous fistula and pronounced cirsoid aneurysms.

Facial Asymmetry.—In several instances retardation of growth of the homolateral side of the face has been described, but Birch-Hirschfeld concluded that this was not of particular significance because of the relative frequency of asymmetry of the face in otherwise normal individuals. There can be no local reason for asymmetry of the face.

The Affected Eye.—It is obvious from consideration of reported cases that the involved eye in a great majority of cases remains normal. When the eye is proptosed and remains so for a considerable time there may be congestion of the bulbar conjunctiva. A relatively small number of the reported cases have had some degree of optic atrophy (14 per cent—Birch-Hirschfeld). In our case the vision was slightly

reduced, 20/30. Birch-Hirschfeld assumed that optic atrophy was due to retrobulbar hemorrhage which is said to be, and doubtless is, an occasional complication. However, a more reasonable assumption in a majority of such cases would appear to be long-sustained direct pressure of the mass on the optic nerve.

Visual acuity may be lowered materially during the exophthalmic phase. Extreme overfilling of the retinal veins has been noted during the period of exophthalmos and they may pulsate but the fundus remains otherwise unchanged. Diplopia, present occasionally in our case, is not usually mentioned. Usually there is no limitation of ocular movements. The pupil remains unchanged in many of these patients, but pupillary dilatation during exophthalmos has been described by several observers listed by Birch-Hirschfeld and was present in our case. Rumjanzewa described narrowing of the pupil during periods of exophthalmos in her case.

Pulsation of the Eyeball.—According to Birch-Hirschfeld, this is rarely present in intermittent exophthalmos. Mention of it was made in only 7 of 74 cases included in the studies of Birch-Hirschfeld and Wissmann and Schulz. The symptom was present in our patient, and was most pronounced during maximum exophthalmos. It is entirely possible that the pulsation has been overlooked in some of the reported cases where it has not been mentioned. However, in many cases special mention has been made of the absence of pulsation and there can hardly be a doubt that it is not always present. In only 1 instance has a subjective murmur or objective bruit been noted. In Delord and Viallefont's case a blowing sound was heard on auscultation. Poole's patient described roaring and tinnitus. Neither was present in our case despite the known arteriovenous communication.

Other Symptoms.—In many cases the condition is asymptomatic, but pain may be the only symptom and it may become steadily more severe. Since pain is associated with protrusion of the eye it may be present most of the time.

A sensation of fullness in the side of the face is frequently noted. In Poole's case the pain became so severe that the patient could not continue his work. Often there is complaint of dizziness and vertigo, usually not severe, and occurring only during periods of exophthalmos. Birch-Hirschfeld in a short discussion (1930) suggested intracranial varices as possibly accounting for these symptoms. Hippert thought venous anomalies influenced the vestibular apparatus in his case.

Roentgenograms.—These have usually been reported as negative. Hippert found a single small calcification in the sphenoidal fissure, but there was a similar one on the other side. Kraupa and Mendl reported small calcifications which they termed phleboliths in two cases. Gastreich saw seven or eight rounded and slightly oval, smooth pea-sized shadows. Lyding reported 12 such shadows in the orbit of his case. Such shadows are well known to occur in the defective walls of cerebral vascular beds, such as arteriovenous aneurysms in the cranial and orbital cavities, and doubtless these calcifications are of similar origin. In our case there were two calcified plaques in the outer orbit (see Fig. 2).

Treatment and Pathology.—Rychener (1942) observed improvement in a case reported by Chapman (1931), and later by Ellett (1940).

The injection of sclerosing solutions into the orbital veins has been advocated by several writers; Hippert found 4 successful results. Ravardino reported a success but Dunphy, a failure after these injections.

The first operative attack upon the large veins of the orbit for intermittent exophthalmos was by Schimanowsky (1907). Through an incision under the eyebrow he clamped and twisted the large vein, perhaps the superior ophthalmic, in the back of the orbit and allowed the clamp to remain 2 days before being withdrawn. A cure of the exophthalmos resulted but with ptosis and ophthalmoplegia; the state of the vision was not given. Three years later he operated on another case in similar fashion except that he tied and cut through the

veins. Precisely the same result was obtained. Löwenstein (1911), through a modified Krönlein approach, palpated venous tortuosities en route to the supra-orbital vein. The bleeding was severe, it was controlled by the Paquelin cautery and the wound packed. During the next few days the exophthalmos was extreme but gradually disappeared by the twelfth day; 4 days later there was an enophthalmos of 3.5 mm. and this persisted. Slight exophthalmos (1.5 mm.) persisted during jugular compression. The inferior rectus muscle was paralyzed; vision was greatly reduced immediately after operation but returned to 4/10 after 4 weeks and to 10/10 after 9 weeks.

Germain and Weill explored the orbit of a patient who had developed retrobulbar hemorrhage and exhibited pronounced exophthalmos. A large number of dilated veins were found within the muscle cone. In attempting to isolate and ligate these veins there was spontaneous hemorrhage. Excision of the veins was performed. The exophthalmos was relieved. Two months later the eye was enophthalmic and there was external ophthalmoplegia. The state of the vision was not recorded.

The only other operated case was reported by Rumjanzewa (1930) and a perfect result was obtained. The ophthalmic vein was ligated in the orbit through a supra-orbital incision; the exophthalmos was cured and without extra-ocular palsies. She called it Golowin's operation—a method of attack used by him on pulsating exophthalmos.

In none of these records of operations is there any mention of pathologic findings except that the veins were large. The exposure of the orbit is doubtless too restricted to define any clear-cut lesion, but on the other hand there is probably nothing in the orbit except large veins. The operation used in our case as detailed above was a transcranial approach which has been evolved for orbital tumors. Since the lesion was intracranial and of a well-recognized type and since it was obliterated intracranially there was no indication to remove

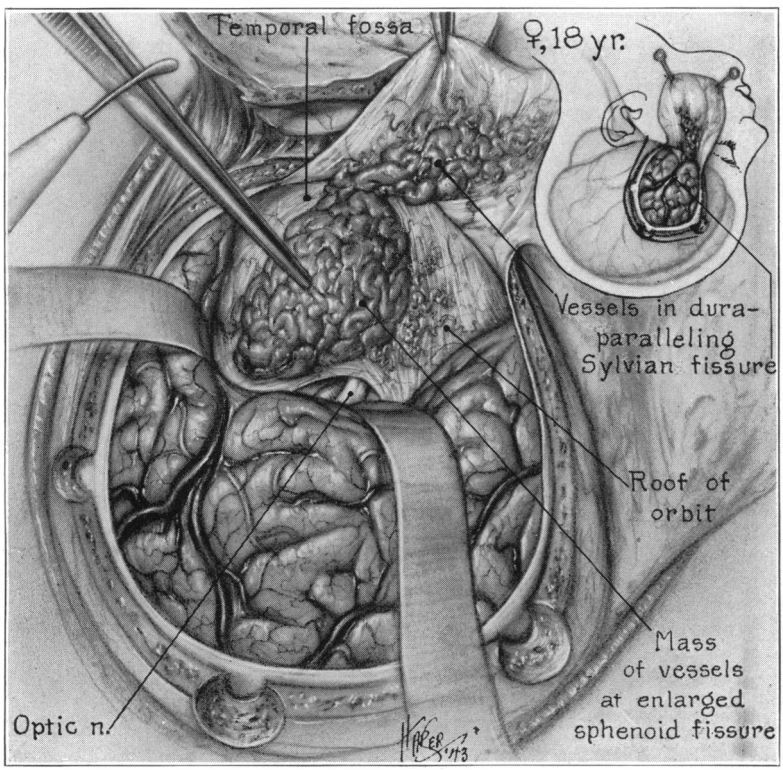

Fig. 3.—Coil of vessels forming an arteriovenous aneurysm that filled the floor of the middle fossa and overflowed around the sphenoidal wing into the dura of the anterior fossa. These vessels contained arterial blood and pulsated.

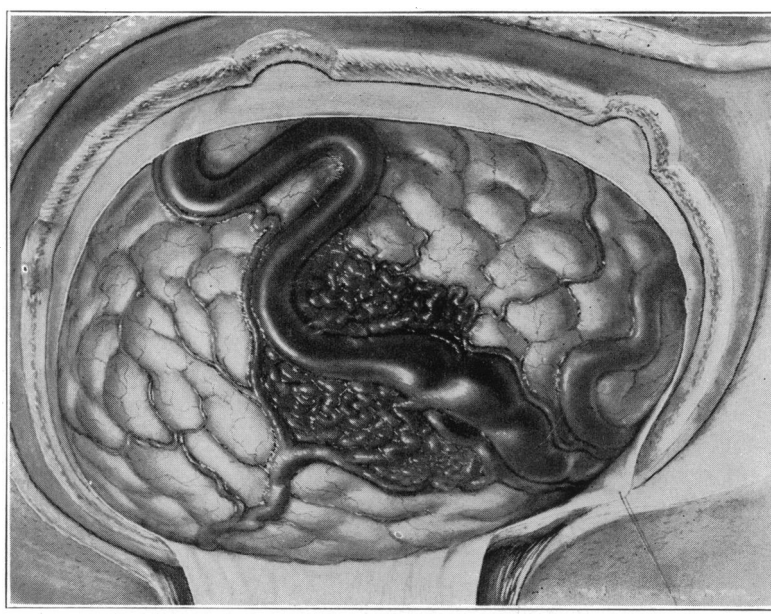

Fig. 4.—Arteriovenous aneurysm of the brain, fundamentally similar to that of the one presented in this paper.

the orbital roof to inspect the orbit. This approach revealed the only extra-orbital lesion that has been identified with intermittent exophthalmos. Had the orbit been explored by a Krönlein approach the character of the underlying lesion would not have been disclosed. This arteriovenous aneurysm (not a single fistula but coils of vessels replacing capillaries but with a larger lumen and of congenital origin) is of exactly the same character as all arteriovenous aneurysms within the brain substance. Several examples of these are shown in a publication by one of us in 1928; 2 photographs of such aneurysms are included here (Figs. 4 and 5).

We do not suggest that the treatment carried out in our case is the best solution of the problem. On the contrary, the result obtained by Rumjanzewa is so much better that in another case we should probably be content to ligate the superior ophthalmic vein and leave the aneurysmal coils alone. The surgical attack is much better and there is consequently less risk of injuring the extra-ocular muscles through the transcranial than through either the Krönlein or frontal approach. The ultimate decision concerning the best type of surgical treatment will, of course, be evolved only after greater experience and after it is known whether lesions of different types may be responsible for this unusual syndrome.

However, there is a serious risk in ligating large veins ahead of an arteriovenous aneurysm. In one of the cerebral aneurysm cases (Fig. 4), another nearby vein ruptured. It must be realized that the great venous bed emerging from the arterio-venous coils is made as an adjustment to the entering arterial blood and reduction in the bed throws a strain on the remaining veins, all of which have relatively weak walls.

DISCUSSION

In our case there could be no preoperative doubt that an arteriovenous aneurysm was causing this syndrome, *i.e.*, because of the pulsation of the eyeball. Nor could it be doubted that it was a "coiled" aneurysm rather than a carotid-

cavernous aneurysm (a fistula) which gives entirely different signs and symptoms, *i.e.*, a murmur, a constant exophthalmos, and dilated pulsating vessels in the conjunctiva and over the forehead. Never is there alternating exophthalmos and enophthalmos with a fistula, nor does the jugular compression affect the protrusion of the eye. The coexisting enophthalmos was new in our experience but was assumed to be due to atrophy from pressure of the dilated veins. It is noteworthy that the space-occupying mass, *i.e.*, the vascular coils, were almost entirely in the cranial chamber and not in the orbit. Had this mass, as large as a walnut, been in the orbit there would have been constant exophthalmos and never enophthalmos. Only the enlarged veins that drained the aneurysm were in the orbit, and the size of these changed with the volume induced by gravity and other physiologic factors affecting venous pressure largely through the corresponding jugular vein.

A glance at Figs. 4 and 5 will show the tremendous effect of arterial pressure upon the size of the veins emerging from a cerebral arteriovenous aneurysm; those of an orbital or extra-orbital aneurysm of similar type will be of precisely the same character.

It is not clear how far the pathologic findings of this case can be applied in all cases of intermittent exophthalmos. All cases with pulsation of the eyeball doubtless have just such a causative lesion. But many, perhaps the majority of reported cases, either did not have pulsation (by special mention of its absence) or the pulsation was missed by the examiner. At least there must always be a large venous bed, but we know of no descriptions of such large venous masses in the orbit. While there are purely venous aneurysms in the brain they are uncommon and they are not known to enlarge progressively. A true angioma would not be quickly influenced by changes in jugular pressure but would simply act as a space-occupying mass giving a constant exophthalmos.

Until there are more pathologic confirmations of the under-

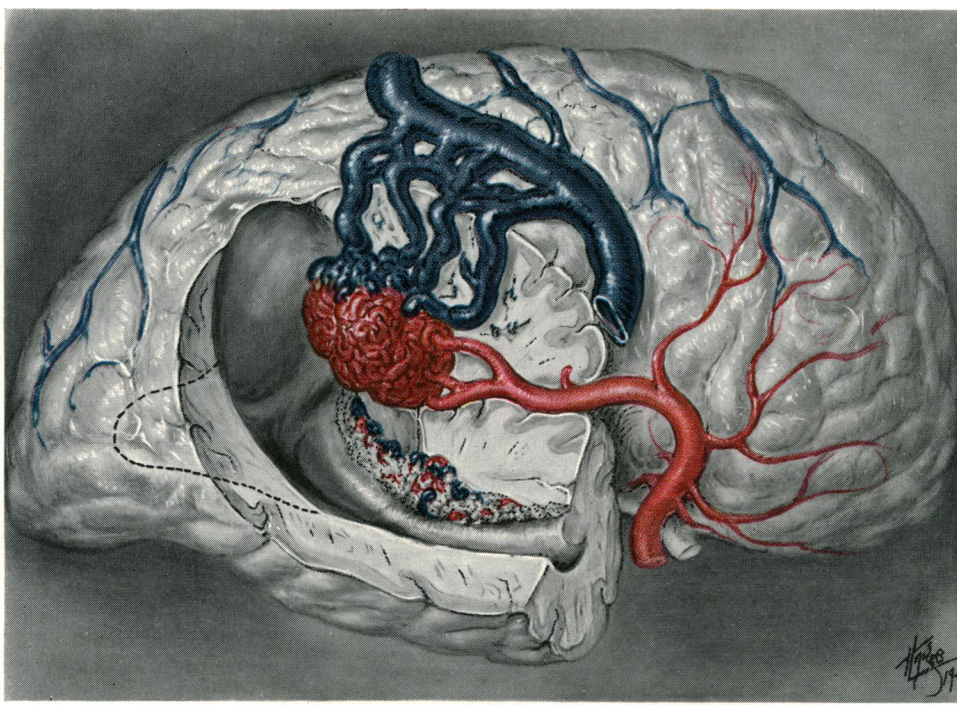

Fig. 5.—Reconstruction of an arteriovenous aneurysm showing a coil of vessels which carry arterial blood and from which the tremendously enlarged veins emerge. This is shown because it is exactly like the arteriovenous aneurysm in this paper.

lying lesions in this condition, a conclusion applicable to all cases is clearly impossible.

It is possible that there are 2 general types of lesion causing intermittent exophthalmos: (1) arteriovenous, with pulsation, and (2) venous without pulsation; but speculation on this score is useless. The arteriovenous type, at least, is certain, the venous problematic. It is our guess that ocular pulsation has been overlooked in many cases. It is never so pronounced as in the usual pulsating exophthalmos from a carotid-cavernous fistula.

Arteriovenous aneurysms are, of course, congenital maldevelopments and never of traumatic origin. This accounts for their early appearance in most recorded cases. It might be asked why they are not present at birth. The answer is that the sustained arterial blood pressure causes the gradually progressive venous enlargement as the vascular coils with defective walls steadily dilate. The exact time of appearance of the syndrome therefore depends upon the resistance of these walls, which must have wide individual variations. Doubtless many open in later life.

CONCLUSIONS

1. A typical case of intermittent exophthalmos is presented.

2. The underlying lesion was found at operation—a transcranial approach—to be an intracranial arteriovenous aneurysm lying in and behind the sphenoidal fissure. This is the only case in the literature in which a cause of this rare syndrome has been disclosed. The source of the arterial part of the aneurysm is not certain; it was thought to be the middle meningeal artery.

3. An arteriovenous aneurysm of similar type is probably responsible for all cases with pulsation of the eyeball. In most cases pulsation was absent or missed. Whether or not there are 2 types of this syndrome, one with, and the other without pulsation, cannot be determined without subsequent pathologic studies. Doubtless in some cases the pulsation was present but was missed by the observer.

4. The intermittent exophthalmos was cured by obliterating the aneurysm with the electrocautery but blindness of the affected eye and ophthalmoplegia resulted.

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DISCUSSION

DR. W. L. BENEDICT, Rochester, Minn.: Intermittent exophthalmos is a rare clinical phenomenon due to venous aneurysm within the orbit and occurs probably only in cases of congenital vascular anomalies. It is to be distinguished from pulsating exophthalmos which usually is the result of trauma, and the authors have defined the terms with that in mind.

Three cases of intermittent exophthalmos have been seen at the Mayo Clinic and only one of them came to operation.

The first was a child 7 years old, referred in 1923 by Dr. J. O. McReynolds. A report of this case was published by Dr. F. H. Newton in the Texas State Journal of Medicine, May, 1924.

At birth, the left eye was out of the socket. It was replaced and kept in position with a bandage until he was one year old. Coughing, crying, or bending forward caused marked protrusion of this eye. For several years the eyeball had frequently been completely dislocated forward between the lids when the child cried vigorously or had a severe coughing spell.

When in the upright position the eye remained fairly prominent, but when lying down the globe receded to its normal position. The vision of this eye has always been poor. An x-ray of the head, made when the patient was 3 weeks old, showed a coloboma in the frontal bone over the left eye. Dr. McReynolds stated in his letter of reference, "Since birth the child has had an intermittent exophthalmos of this (left) eye, but the pulsation has been very slight or altogether absent until a few days ago. The marked pulsation which you will see on examination developed suddenly while the child was observing a motion picture. Since that time, a bandage has been required continuously and the child has been suffering considerable pain."

When the bandage was removed the left eye proptosed and pulsated distinctly with considerable pain. The upper lid was discolored and cyanosed. The eyeball was displaced laterally. Palpation over the left frontal region showed practically lack of bone. The retinal veins engorged, otherwise the fundus was negative.

Ligation was advised and arranged for but the patient's parents refused surgery. In reply to my inquiry made in April, 1944, Dr. Newton replied as follows:

"The condition of the left eye has remained practically unchanged during the last 20 years.

"Our last examination was made on September 21, 1943, at which time the patient gave a history of having received a head

injury in a brawl of some kind 24 hours previous to the examination. X-rays made by a neurologist showed a fractured skull. A decompression operation to relieve the pressure of an extradural hemorrhage was performed. He snapped out of this, and is apparently as good as he was before.

"The last visual examination was made on November 7, 1941, at which time the vision in the right eye was 20/20ths, and the vision in the left eye was 20/200ths. As stated above, I am not able to determine any particular difference in the condition of the eye."

The second case was that of a boy, aged 4 years, seen April 23, 1925. He was brought to the Clinic by his parents because of bloodshot right eye of one week's duration. The first trouble with the eye was noticed 2 years previously when it suddenly bulged forward. The child cried with pain. The eye receded quickly with disappearance of the pain, the whole procedure lasting 15 minutes. This happened twice in the same day. Since then the eye has been noticeably prominent many times, particularly on laughing or crying, but without pain. Vision could not be satisfactorily tested but seemed to be good.

The right eye was more prominent than the left. Exophthalmometer readings were right 22, left 14. There was diffuse subconjunctival hemorrhage throughout the eye, and hyphemia. The iris was yellowish green, the pupil 4 mm. in diameter, reactions normal, tension normal. During examination the child's struggles greatly increased the proptosis, advancing and receding with each straining effort. Ophthalmoscopic examination showed the media to be clear, the disc slightly pale, vessels normal, and no pulsation of retinal vessels.

This patient was examined by Dr. W. I. Lillie, who advised no treatment at the time but urged re-examination after a few months. The patient never returned and I have no further information regarding him.

The third case was that of a young woman aged 19 years who was referred by Dr. Murray F. McCaslin of Pittsburgh in November, 1939, and reported by Dr. J. G. Love in the Proceedings of the Staff Meeting of the Mayo Clinic, 16: 409–410.

In 1936, 3 years before coming to the Clinic, she first noticed that the right orbit seemed to become full and the eye protruded whenever she would suddenly stand up or bend forward at the waist. This proptosis was not visible until about one and a half years later. About one year before she came to the Clinic the protrusion became progressively more apparent. She would push the

eye back each time it would protrude. This was only to speed up the progress, for it always regressed by itself but at times took considerable time to do so. She also noticed that the right eye could be pushed farther back into the orbit than could the left eye and that sometimes it was more easily pushed back than at others. She had no pain with the protrusion, only a sense of fullness of the orbit. During the year prior to her admission to the Clinic the vision in the right eye was blurred when it was protruded but cleared as soon as the eye receded into the orbit. In June, 1939, the vision of the right eye was completely lost for a time and she noticed that she could see only the right half of an object viewed with the left eye. This persisted for 90 minutes, following which the right eye was sunken more deeply into the orbit than usual.

Examination on November 14, 1939: Vision without correction 6/6 in each eye, for near 14/14. On general inspection the eyelids were full, apparently ptosed, but retraction was satisfactory. Exophthalmometer reading: 15 O. U. After holding the head down for some time a subjective sensation of fullness of the orbit came on but upon sitting erect this immediately disappeared. There was no pulsation nor bruit anywhere about the orbit when the head was erect or dependent. She had never felt any pulsation or heard any thrill in connection with the forward movement of the head. The eye was not proptosed when lying in bed. It usually occurred when she stood quickly from a sitting position. The right eye would protrude if she lay on the left side. The fundus examination was entirely negative. Electro-encephalographic report: "Except for a cortical suppression of plus 1–2, the EEG was normal. There was no evidence of a focus or of seizure activity. A diagnosis of venous aneurysm of the orbit was made."

A right transfrontal craniotomy was done on November 23, 1939, by Dr. J. G. Love. "A right transfrontal flap such as is used for chiasmal lesions was turned down and, when the dura was elevated from the roof of the right orbit, a bluish discoloration was noted in the middle and outer thirds due to an underlying vascular lesion. The roof of the orbit over the greater portion was removed and it was unusually thin, particularly in the middle and posteriorly toward the optic canal. The periorbita in the mesial third was normal in color, whereas in the middle and outer thirds it was distinctly bluish. When the periorbita was incised, it was found to be densely adherent to the underlying angioma. In attempting to free the angioma from the periorbita it was ruptured and there was very sharp venous bleeding. Only small bits of the angioma were

removed but the entire mass was collapsed and some of the bleeding was controlled with the electrosurgical unit, but it was necessary, in addition, to use one fairly large pledget of muscle against which we applied suction on a cottonoid strip. This controlled all bleeding. The dura was not opened for it was obvious that the findings within the orbit which were seen by Drs. Benedict and Woltman were sufficient to account for the patient's symptoms."

The eyes were normal for 3 years. Then in September, 1940, Dr. McCaslin noted a return of symptoms similar to the onset 3 years previously. The eye did not come forward on stooping nor was there any disturbance of vision. There was apparently an arterial involvement that did not exist prior to the operation.

In a recent letter Dr. McCaslin states: "Miss B. O. was in Saturday, May 13, 1944, for a recheck, and I found that her vision still remains 20/15 in each eye. The fundi are negative, and fields are normal. The eyeball protrudes 4 mm., as it did on the original examination, when she stoops over. When coming to an erect position, the eye returns to a normal position, and, on reclining, the eyeball does not recede as it did formerly. She does not have any visual disturbance and her bizarre mental condition has cleared up."

DR. RALPH I. LLOYD, Brooklyn, N. Y.: I wish to show a slide of a man who came to my office whose eye popped out if the lids were separated. The pain was severe and it was difficult to get him to hold still while I took a single snapshot. He complained that if he laid down without first applying a compress bandage over both eyes, the lowermost would pop out and he could not wait to get a towel to use in pushing the eye back into place. His vision was normal and there was no muscle error.

DR. WALSH, closing: I wish to thank Dr. Benedict for his interesting comments and Dr. Lloyd for showing pictures of an interesting case.

It is gratifying that Dr. Benedict seems in agreement regarding developmental vascular abnormalities producing intermittent exophthalmos.

I am not entirely satisfied that Dr. Lloyd's case falls into the group which has been described. If it does not it is unique as a case of bilateral intermittent exophthalmos.

As regards surgical intervention when indicated in such cases, Dr. Benedict seems in agreement regarding the transcranial approach.